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Technical Equivalency Documentation for a New Alpha Spectroscopy System

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Introduction

The response of a new Canberra™ Alpha Analyst (Chamber #'s 101 – 124) used by the Hazards Control, Radiation Safety Section, WBC/Spectroscopy Team has been studied with respect to an existing Canberra system. The existing Canberra system consists of thirty six Model 7401 alpha spectrometry chambers (Chamber #'s 1-36) and has been DOELAP qualified for the routine Alpha Spectroscopy program used in LLNL's *in vitro* bioassay program. The new Alpha Analyst system is an automated system that is controlled by the same software and computer system as that used for the existing Canberra system. This document compares results from the existing Alpha System with the newer Alpha Analyst system.

Methods

Standard quality control measures were evaluated on the new Alpha Analyst system and compared with the older Alpha system. Quality control measures that were compared consisted of Pulser counts, Background counts, and Calibration/efficiency as measured with NIST traceable standards.

Compared parameters for the Pulser measurements were the full width half maximum (FWHM), Energy, Centroid, and count rate. The average values of these parameters were compared to the Quality control limits established in Section 8.8 for the WBC/Spectroscopy procedures manual. Average values for these parameters on the older Alpha Spectroscopy system were also provided for comparison.

Compared parameters for the Background measurements were the average counts obtained for a 2.5 day background count in the Pu-239 and Am-241 regions. Background rates for both the older Alpha and newer Alpha Analyst systems were evaluated.

Comparison of the Prime parameters was performed for the deviation of the Prime source radionuclide known activities to the average activity computed by each system. The average efficiencies were also compared.

Comparison counts of routine samples counts containing known quantities of internal tracer were performed on the existing Alpha system and on the first 24 chambers (101 – 124) of the new Alpha Analyst (AA) system. Each individual AA detector had at least 5 comparative counts associated with 5 different detectors from the ALPHA system. Parameters that were compared were tracer data (Pu-242 and Am-234) and positive count data for Pu-239, Pu-238, U-234, U238, Gross Actinides Low Energy Region (GA1) and Gross Actinide High Energy Region (GA3). Comparison was performed by an analysis of variance for the entire system. These tests were followed by subsidiary Analysis of Variance (ANOVA) tests of individual detectors within the AA system when possible.

A total of 294 sample count comparisons were made.

Conclusions

The Pulser FWHM, Centroid Energy, and Centroid Channel for the existing Alpha system and the new Alpha Analyst system provide consistent results that are well within established limits for these parameters. Overall, the measured pulse rates for both systems are measured to within a few percent (Tables 1 & 2). This demonstrated stability in the pulser signal measurements indicates that the system is stable from count period to count period.

The background for the Alpha Analyst system is lower than the background for the existing Alpha system (Table 3). The background for the existing Alpha system is comprised of greater than 10 years of data, and exhibits a higher average background due to high usage over this period.

The average computed activity when measuring the Prime calibration sources is typically a few percent of the known standard activity (Table 4). The average efficiency for the Alpha Analyst system is slightly lower than the average efficiency observed for the existing Alpha system (Table 5). This change in efficiency could be due to the recoil suppression methodology employed by the Alpha Analyst system or due to slight differences in shelf distance from the source to the detector employed by each system. Regardless, the average efficiency of both systems is adequate to assure detection level (Lc) criteria established by the Internal Dosimetry Team.

There were sufficient numbers of comparative sample measurements that contained Pu-242 tracer to evaluate each detector of the Alpha Analyst system with measurements of the same sample sets on multiple detectors of the existing Alpha system. There was a non-significant difference between the Alpha Analyst measurements of Pu-242 and measurements of the same samples performed on the existing Alpha system (Table 6 and ANOVA result tables).

Finally, analyses of positive sample results for other radionuclides were evaluated for all detectors. There was a non-significant difference between the Alpha Analyst measurements for U-234, U-238, Am-241, Pu-238, Pu-239, Low Energy Gross Actinide region (GA1), High Energy Gross Actinide region (GA3), and Am-243 tracer and measurements of the same samples on the existing Alpha system (see ANOVA result tables).

Results

Table 1. Pulser Measurement comparison – Alpha Analyst System[1]

Detector	FWHM (keV)	Energy (keV)	Centroid Channel	Rate (cps)
101	11.03	5051	514.7	41.53
102	11.12	5045	514	41.53
103	11.03	4998	499.4	41.53
104	11.37	4993	500	41.54
105	12.24	4998	496	41.54
106	11.64	4992	497	41.54
107	12.85	4998	494.9	41.54
108	11.13	4987	499.2	41.54
109	11.43	4987	499.5	41.52
110	11.33	4987	499.8	41.51
111	11.62	4988	497	41.51
112	11.35	4981	498.5	41.51
113	18.34	4996	489.4	41.52
114	11.04	4995	492	41.52
115	11.21	4994	489.1	41.52
116	15.72	5002	491.6	41.5
117	14.92	5005	494	41.52
118	12.01	4990	493	41.52
119	12.69	4999	490.9	41.52
120	15.18	5001	492	41.52
121	13.54	4987	491.3	41.52
122	11.91	4992	493.8	41.52
123	15.93	4991	490.7	41.52
124	13.35	4986	490.7	41.51
Average	12.67	4998	496.2	41.52
Established Limits:	8 - 20 keV	4900 - 5100 keV	480 - 540 keV	39 - 43 cps

*Average values of pulser parameters measured to date

[1] The pulser rates for the two systems are different due to the different clock speeds of the pulse generator contained in each system.

Table 2. Pulser Measurement comparison – Alpha System[2]

Detector	FWHM (keV)	Energy (keV)	Centroid Channel	Rate (cps)
1	10.73	4990	504.2	509
2	12.25	5031	519.3	498.5
3	14.25	4995	503.1	511.7
4	12.23	4999	508.8	514.7
5	11.43	5042	522.1	495.7
6	11.4	4996	502.7	508.3
7	11.56	5006	506.2	506.6
8	10.77	5059	530.1	511
9	10.93	4967	499.8	511.1
10	11	5045	517.5	494
11	12.85	5050	521.5	510.3
12	11.63	4984	502	512
13	10.8	5022	520	500.1
14	13.22	4987	507	509.9
15	14.13	5048	521.9	499.8
16	13.92	5055	520.4	507
17	12.17	4966	494.9	511.7
18	17.32	4992	507.5	509.2
19	11.18	5050	520.2	510
20	11.61	4952	510.7	510.7
21	11.78	5043	508.2	498.5
22	11.91	5051	523.8	500.8
23	14.13	4990	503.4	502.5
24	12.73	5003	510	506.1
25	13.94	4963	504	501.7
26	10.92	5058	522.7	513.2
27	14.14	5052	521.2	508.2
28	14.75	4983	500.6	515.9
29	12.13	4969	495.8	510.1
30	10.25	5058	522.7	505.2
31	11.02	5063	520.7	518.4
32	12.77	4972	496.3	510.3
Average	12.37	5014	511.5	507.3
Established Limits:	8 - 20 keV	4900 - 5100 keV	480 - 540 keV	475 - 525 cps

*Average values of pulser parameters measured to date

[2] The pulser rates for the two systems are different due to the different clock speeds of the pulse generator contained in each system.

Table 3. Average background for 2.5 days of background counting.

ALPHA			ALPHA ANALYST		
Detector	**Pu-239**	**Am-241**	**Detector**	**Pu-239**	**Am-241**
1	4.49	3.14	101	0.88	0.88
2	4.06	3.50	102	1.18	0.53
3	5.28	2.93	103	0.59	0.53
4	3.67	2.99	104	1.06	1.00
5	3.37	2.78	105	1.29	0.35
6	4.68	3.55	106	0.82	0.59
7	2.96	3.16	107	0.88	0.41
8	3.18	4.68	108	0.82	0.65
9	3.35	2.72	109	1.00	0.94
10	4.61	4.30	110	0.71	0.59
11	2.98	3.08	111	1.06	0.47
12	3.32	3.13	112	0.88	0.94
13	3.61	3.81	113	0.77	0.77
14	3.23	2.61	114	1.12	0.65
15	3.97	3.12	115	1.24	0.77
16	3.19	3.69	116	1.06	0.19
17	3.22	2.81	117	1.41	0.41
18	4.62	3.68	118	1.31	0.63
19	3.88	3.98	119	1.24	0.53
20	3.63	3.28	120	1.20	0.40
21	2.43	2.32	121	1.94	1.29
22	3.80	3.81	122	1.29	1.10
23	3.48	3.64	123	1.63	0.81
24	4.57	5.70	124	0.94	0.56
25	4.02	3.18			
26	3.88	3.53			
27	3.90	3.51			
28	4.02	4.22			
29	3.92	3.63			
30	4.29	4.04			
31	4.31	4.43			
32	4.45	3.76			

Table 4. Percent difference from the average computed activity to the known activity for radionuclides contained in the Prime calibration sources.

		Alpha				Alpha Analyst				
Prime Calibration Source ID	Alpha Detector No.	U-238	U-234	Pu-239	Am-241	AA Detector No.	U-238	U-234	Pu-239	Am-241
311	1	3%	1%	1%	-1%	101	2%	-1%	1%	-2%
312	2	2%	2%	1%	0%	102	-1%	-1%	4%	-2%
313	3	3%	2%	2%	0%	103	4%	-2%	-2%	-1%
314	4	1%	0%	-1%	0%	104	0%	-1%	0%	1%
315	5	1%	0%	-1%	1%	105	2%	-1%	0%	-1%
316	6	1%	-1%	0%	0%	106	3%	-1%	0%	-1%
317	7	2%	0%	-1%	-2%	107	1%	-1%	1%	-2%
318	8	2%	0%	-1%	0%	108	0%	-1%	1%	-1%
3985	9	1%	0%	1%	-2%	109	0%	1%	1%	-3%
3986	10	0%	-1%	0%	-2%	110	2%	-2%	-1%	-3%
3987	11	0%	-1%	1%	-1%	111	1%	1%	-3%	0%
3988	12	-3%	0%	0%	1%	112	-5%	0%	1%	1%
311	13	4%	-2%	-2%	0%	113	0%	1%	0%	-2%
312	14	1%	0%	-1%	0%	114	-1%	1%	-3%	1%
313	15	4%	-1%	-1%	-1%	115	1%	0%	2%	-2%
314	16	1%	-1%	-1%	0%	116	2%	-2%	-1%	1%
315	17	1%	-1%	0%	-1%	117	0%	-1%	2%	-1%
316	18	-2%	2%	-1%	0%	118	-2%	0%	1%	0%
317	19	1%	0%	0%	-2%	119	0%	1%	-1%	-1%
318	20	3%	0%	-3%	0%	120	3%	-1%	0%	-1%
3985	21	1%	0%	2%	-3%	121	3%	1%	0%	-3%
3986	22	1%	-3%	0%	0%	122	1%	-2%	-4%	0%
3987	23	-5%	-8%	5%	1%	123	0%	0%	0%	-1%
3988	24	-1%	2%	0%	-1%	124	-2%	1%	0%	0%
311	25	-1%	0%	1%	0%					
312	26	2%	-1%	-1%	-1%					
313	27	1%	-2%	-1%	1%					
314	28	1%	-1%	-2%	1%					
315	29	-2%	2%	-1%	0%					
316	30	0%	0%	0%	-1%					
317	31	0%	0%	1%	-1%					
318	32	3%	3%	-4%	-2%					
3985	33	1%	2%	-1%	-1%					
3986	34	4%	-7%	-3%	-1%					
3987	35	-1%	-3%	2%	0%					
3988	36	-3%	2%	0%	0%					

Table 5. Comparison of average Prime source efficiencies for the Alpha and the Alpha Analyst systems.

Calibration Source ID	Alpha Detector No.	Efficiency	AA Detector No.	Efficiency
311	1	0.347	101	0.315
312	2	0.365	102	0.307
313	3	0.353	103	0.308
314	4	0.344	104	0.316
315	5	0.342	105	0.314
316	6	0.351	106	0.312
317	7	0.354	107	0.318
318	8	0.36	108	0.307
3985	9	0.353	109	0.293
3986	10	0.356	110	0.304
3987	11	0.343	111	0.303
3988	12	0.357	112	0.301
311	13	0.353	113	0.3
312	14	0.349	114	0.305
313	15	0.353	115	0.3
314	16	0.353	116	0.302
315	17	0.345	117	0.311
316	18	0.339	118	0.309
317	19	0.378	119	0.298
318	20	0.335	120	0.296
3985	21	0.342	121	0.31
3986	22	0.346	122	0.295
3987	23	0.337	123	0.309
3988	24	0.37	124	0.307
311	25	0.35		
312	26	0.353		
313	27	0.373		
314	28	0.342		
315	29	0.345		
316	30	0.36		
317	31	0.332		
318	32	0.336		
3985	33	0.372		
3986	34	0.368		
3987	35	0.325		
3988	36	0.365		

Table 6. Comparison of Average Pu-242 Tracer Activity (dpm) measured in samples measured on both the AA and Alpha systems.

AA Detector	ALPHA[3] Mean		1s	AA Mean		1s
101	1.28	+/-	0.33	1.30	+/-	0.34
102	1.29	+/-	0.37	1.27	+/-	0.35
103	1.22	+/-	0.40	1.20	+/-	0.40
104	1.27	+/-	0.33	1.26	+/-	0.34
105	1.41	+/-	0.08	1.40	+/-	0.08
106	1.27	+/-	0.35	1.27	+/-	0.37
107	1.42	+/-	0.09	1.41	+/-	0.08
108	1.32	+/-	0.20	1.31	+/-	0.19
109	1.43	+/-	0.21	1.37	+/-	0.16
110	1.36	+/-	0.06	1.35	+/-	0.09
111	1.36	+/-	0.32	1.31	+/-	0.29
112	1.30	+/-	0.40	1.28	+/-	0.41
113	1.42	+/-	0.07	1.42	+/-	0.06
114	1.29	+/-	0.34	1.24	+/-	0.33
115	1.35	+/-	0.13	1.39	+/-	0.08
116	1.37	+/-	0.31	1.35	+/-	0.30
117	1.39	+/-	0.17	1.39	+/-	0.17
118	1.35	+/-	0.12	1.38	+/-	0.13
119	1.41	+/-	0.10	1.41	+/-	0.13
120	1.37	+/-	0.13	1.38	+/-	0.14
121	1.46	+/-	0.09	1.44	+/-	0.06
122	1.37	+/-	0.19	1.39	+/-	0.16
123	1.25	+/-	0.37	1.22	+/-	0.38
124	1.40	+/-	0.12	1.38	+/-	0.14
All	1.36	+/-	0.21	1.36	+/-	0.21

[3] Multiple Alpha system detectors used.

ANOVA Results

Pu-242 Tracer Activity ANOVA – all AA detectors

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	5.204	1	5.204	252.678	0.000
RESIDUAL	4.614	224	0.021		

Pu-242 Tracer Activity ANOVAs – by detector

Detector 101

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.903	1	0.903	495.970	0.000
RESIDUAL	0.013	7	0.002		

Detector 102

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	1.048	1	1.048	223.859	0.000
RESIDUAL	0.037	8	0.005		

Detector 103

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	1.259	1	1.259	322.153	0.000
RESIDUAL	0.027	7	0.004		

Detector 104

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.777	1	0.777	205.064	0.000
RESIDUAL	0.023	6	0.004		

Detector 105

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.025	1	0.025	7.166	0.037
RESIDUAL	0.021	6	0.003		

Detector 106

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.164	1	0.164	134.536	0.000
RESIDUAL	0.006	5	0.001		

Detector 107

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.688	1	0.688	332.826	0.000
RESIDUAL	0.008	4	0.002		

Detector 108

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.229	1	0.229	42.758	0.001
RESIDUAL	0.032	6	0.005		

Detector 109

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.156	1	0.156	39.020	0.001
RESIDUAL	0.024	6	0.004		

Detector 110

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.060	1	0.060	20.389	0.001
RESIDUAL	0.026	9	0.003		

Detector 111

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.844	1	0.844	85.655	0.000
RESIDUAL	0.079	8	0.010		

Detector 112

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	1.483	1	1.483	1568	0.000
RESIDUAL	0.008	8	0.001		

Detector 113

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.024	1	0.024	12.341	0.007
RESIDUAL	0.017	9	0.002		

Detector 114

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.672	1	0.672	13.473	0.008
RESIDUAL	0.349	7	0.050		

Detector 115

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.127	1	0.127	8.459	0.020
RESIDUAL	0.120	8	0.015		

Detector 116

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.905	1	0.905	111.214	0.000
RESIDUAL	0.095	7	0.008		

Detector 117

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.258	1	0.258	37.280	0.000
RESIDUAL	0.069	10	0.007		

Detector 118

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.102	1	0.102	31.966	0.000
RESIDUAL	0.026	8	0.003		

Detector 119

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.073	1	0.073	30.619	0.001
RESIDUAL	0.019	8	0.002		

Detector 120

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.125	1	0.125	30.269	0.001
RESIDUAL	0.029	7	0.004		

Detector 121

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.021	1	0.021	16.164	0.003
RESIDUAL	0.012	9	0.001		

Detector 122

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.115	1	0.115	7.020	0.026
RESIDUAL	0.147	9	0.016		

Detector 123

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	1.383	1	1.383	473.957	0.000
RESIDUAL	0.026	9	0.003		

Detector 124

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.091	1	0.091	14.370	0.009
RESIDUAL	0.038	6	0.006		

Am-243 Tracer Activity ANOVA – all detectors

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	10.794	1	10.794	1928.22	0.000
RESIDUAL	0.319	57	0.006		

ANOVA of Positive GA1 samples counted on AA and ALPHA

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.018	1	0.018	63.022	0.000
RESIDUAL	0.008	28	0		

ANOVA of Positive GA3 samples counted on AA and ALPHA

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	2.205	1	2.205	15937.8	0.000
RESIDUAL	0.003	20	0		

ANOVA of Positive Pu-239 samples counted on AA and ALPHA

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	15.779	1	15.779	4341.96	0.000
RESIDUAL	0.076	21	0.004		

ANOVA of Positive Pu-238 samples counted on AA and ALPHA

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	6.631	1	6.631	3319.25	0.000
RESIDUAL	0.016	8	0.002		

ANOVA of Positive Am-241 samples counted on AA and ALPHA

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.047	1	0.047	142.141	0.000
RESIDUAL	0.006	18	0		

ANOVA of Positive U-234 samples counted on AA and ALPHA

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.003	1	0.003	61.007	0.000
RESIDUAL	0.001	28	0		

ANOVA of Positive U-238 samples counted on AA and ALPHA

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.001	1	0.001	27.85	0.000
RESIDUAL	0.001	25	0		